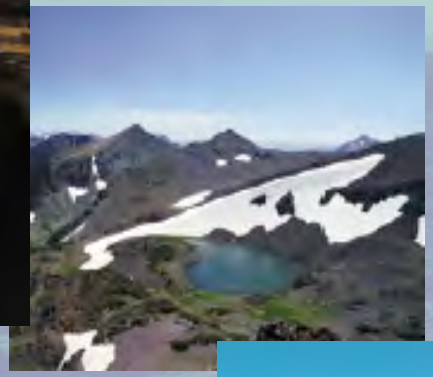
Greenhouse Gas Emissions, Global Climate Models, and California Climate Change Impacts

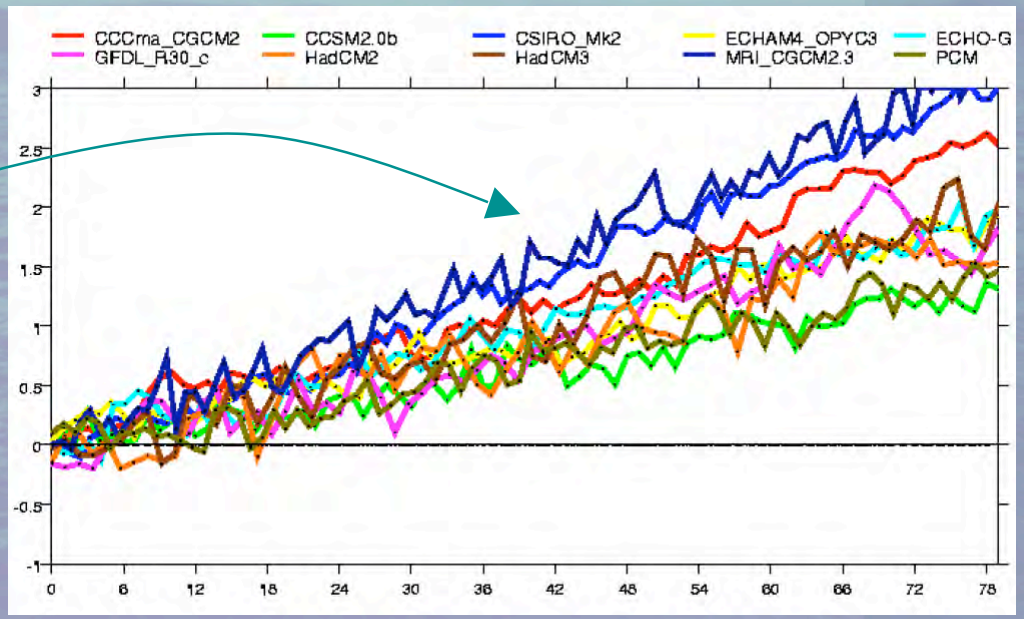


GCM Selection

The projected future climate depends on the Global Climate Model (GCM) used:

- Different parameterization of physical processes (e.g., clouds, precipitation)
- Varying sensitivity to changes in atmospheric forcing (e.g. CO2, aerosol concentrations)

Global mean air temperature by 10 GCMs identically forced with CO_2 increasing at 1%/year for 80 years



Future GHG Emissions

How society changes in the future:

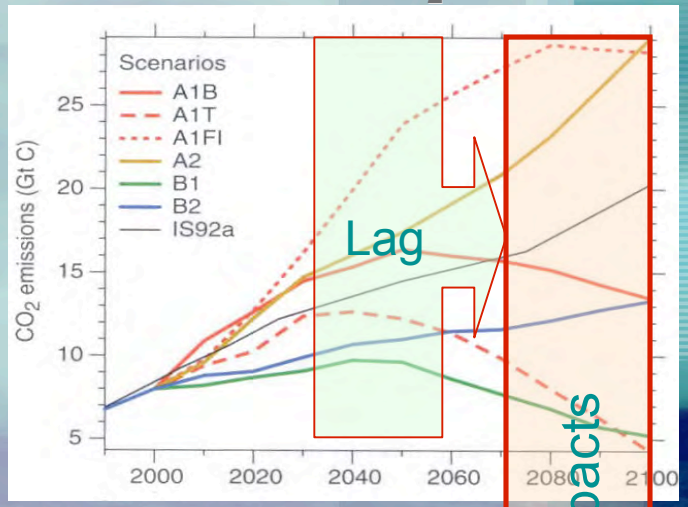
"Scenarios" of greenhouse gas emissions:

A1fi: Rapid economic growth and introduction of new, efficient technologies, technology emphasizes fossil fuels – Highest estimate of IPCC

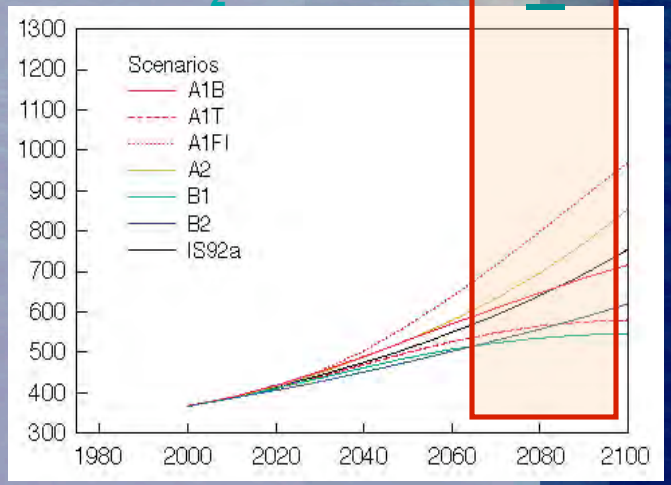
A2: Technological change and economic growth more fragmented, slower, higher population growth – Less high for 21st century

B1: Rapid change in economic structures toward service and information, with emphasis on clean, sustainable technology. Reduced material intensity and improved social equity - Lowest estimate for 21st century

Scenarios of CO_2 emissions



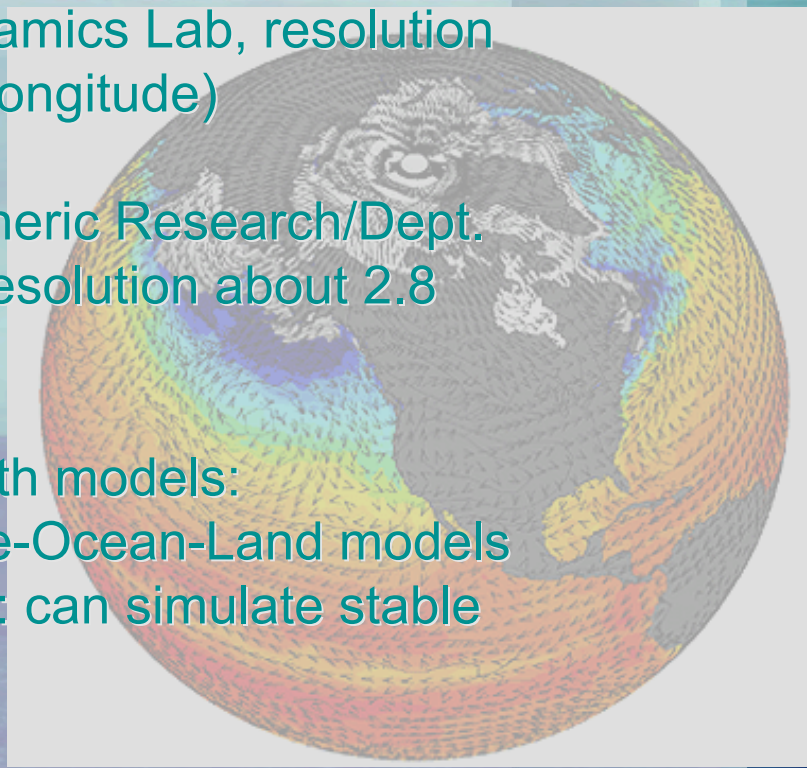
CO_2 concentrations



Governor's Study selected 2 GCMs

GFDL 2.1 – Geophysical Fluid Dynamics Lab, resolution about 2.0 x 2.5 degrees (latitude x longitude)

PCM – National Center for Atmospheric Research/Dept. of Energy Parallel Climate Model, resolution about 2.8 degrees

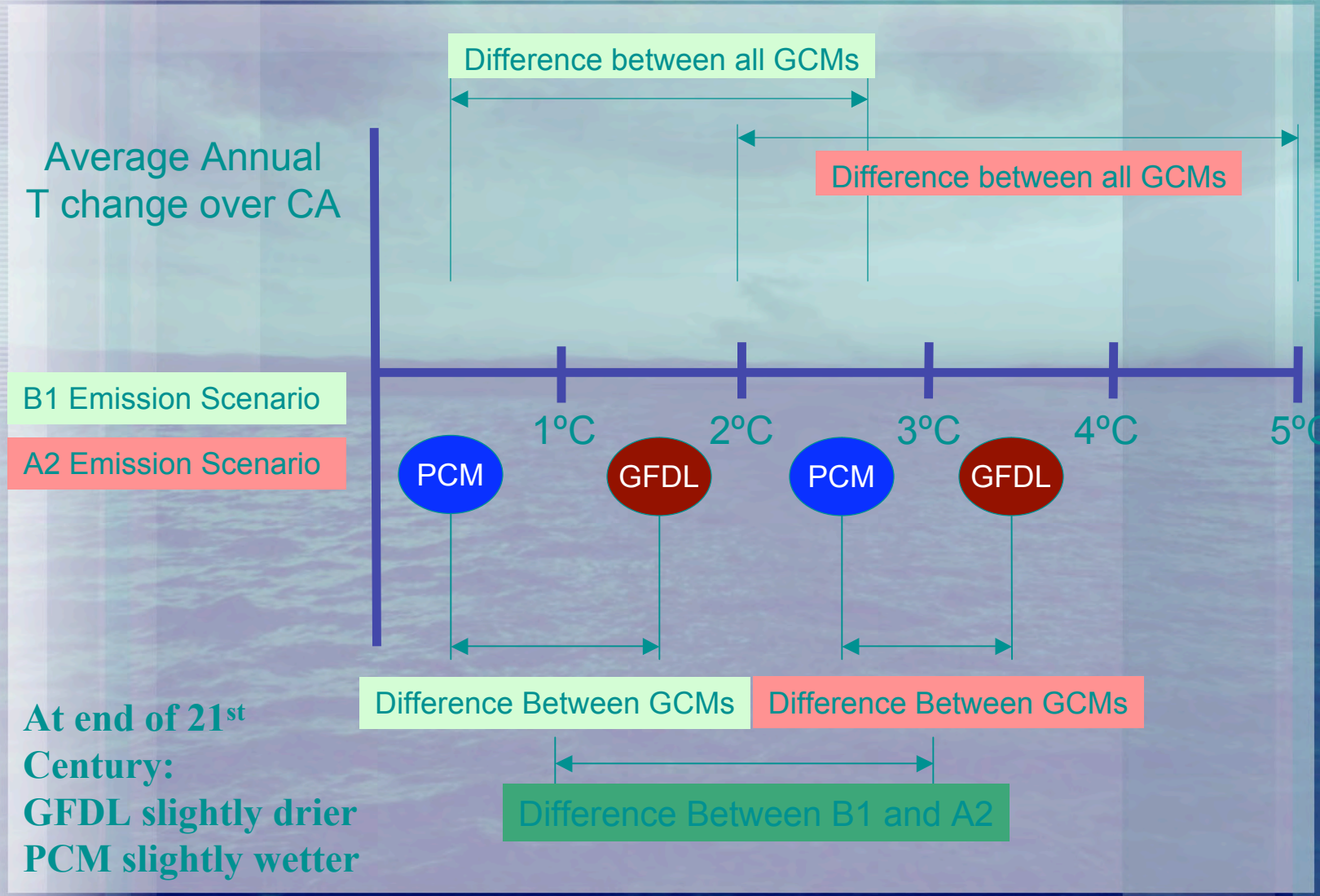


Distinguishing Characteristics of both models:

- Both are Coupled Atmosphere-Ocean-Land models
- Neither uses flux adjustments: can simulate stable climate without adjustments
- Both are state-of-the-art
- Participating in IPCC AR4 simulations archived at PCMDI
- realistic simulation El Niño SST anomalies

GFDL is considered *"Medium Sensitivity"*
PCM generally *"Low Sensitivity"*

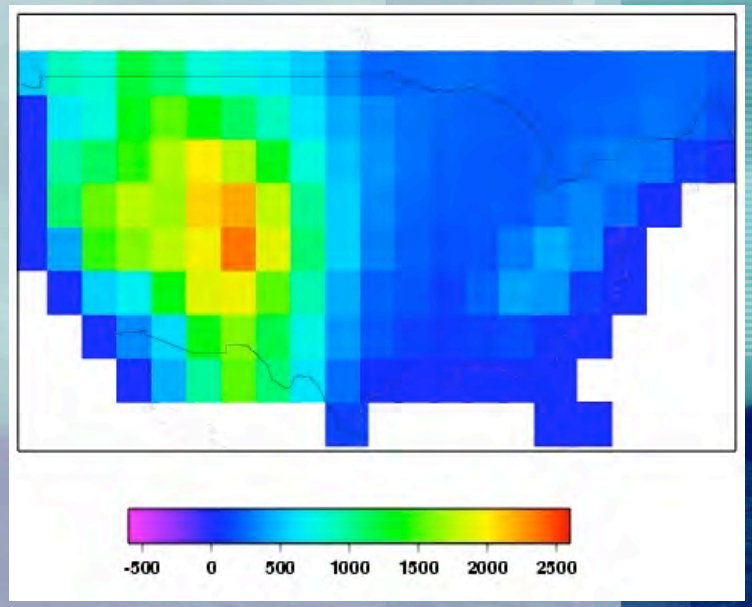
GCM Selection



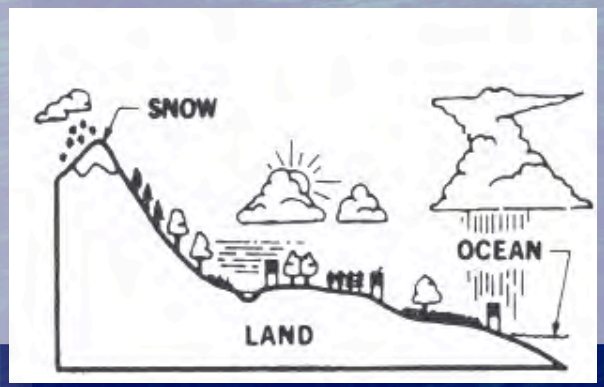
At end of 21st Century:
GFDL slightly drier
PCM slightly wetter

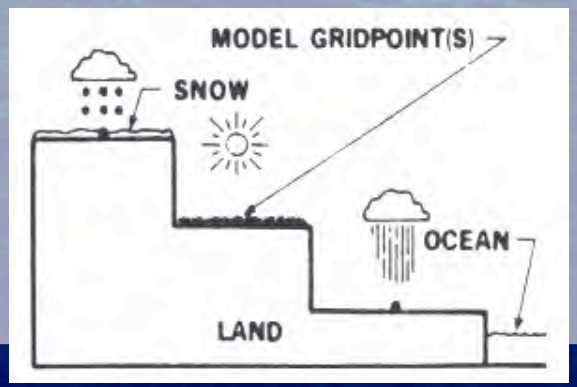
Using GCMs in Impact Studies

- The problems:
  - GCM spatial scale incompatible with local/regional processes
    - roughly 2 – 5 degrees resolution
    - some important processes not captured
  - GCMs have biases



- Resolved by:
  - Bias Correction
  - Spatial Downscaling



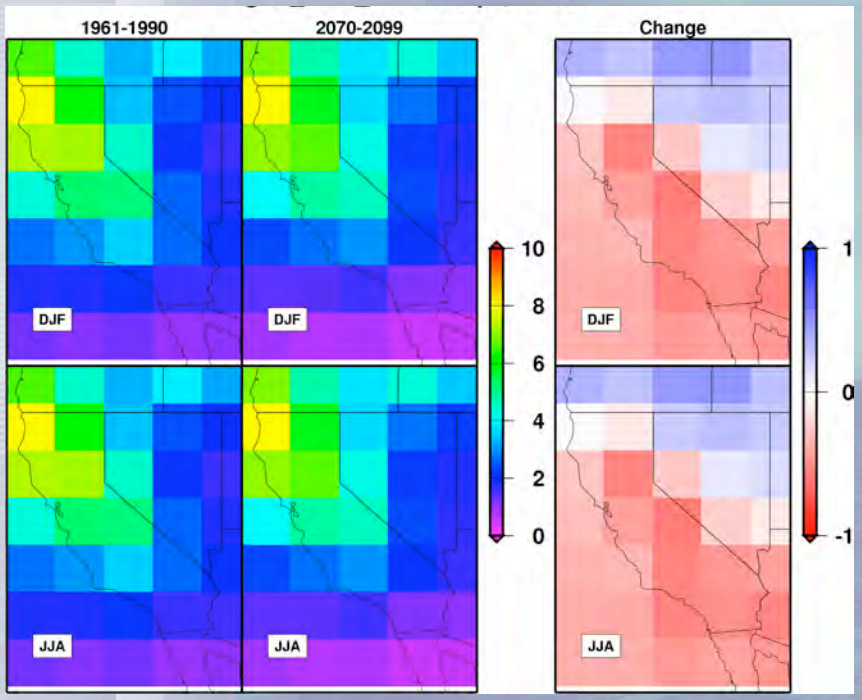


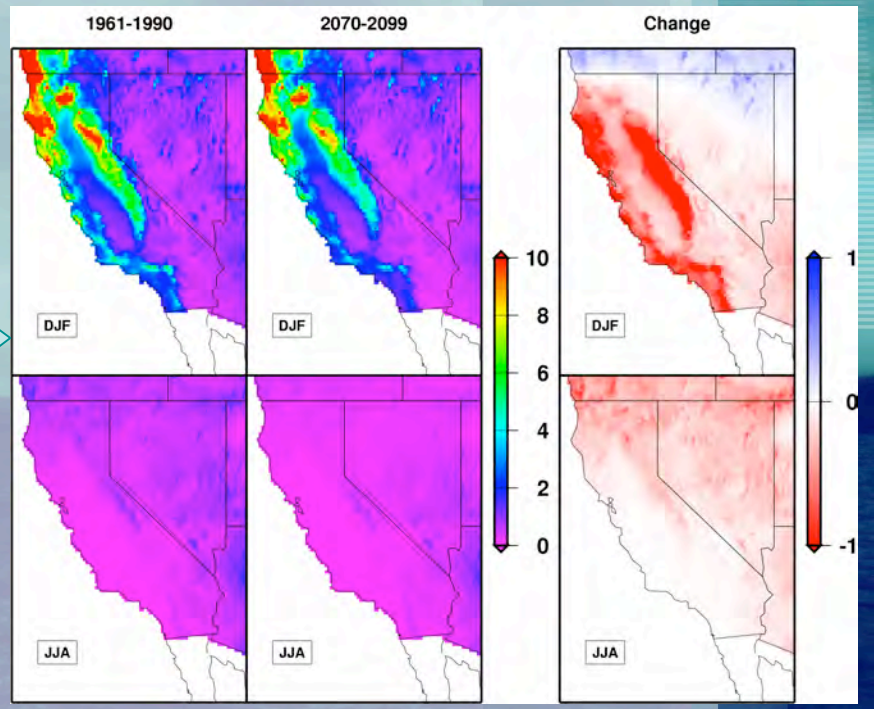
Bias Correction Effects

- Mean and variability of observed data are reproduced for historical period
- Temperature trends into future in GCM output are preserved
- Relative changes in mean and variance in future period GCM output are preserved, mapped onto observed variance

Spatial Disaggregation

GFDL – A2 Scenario





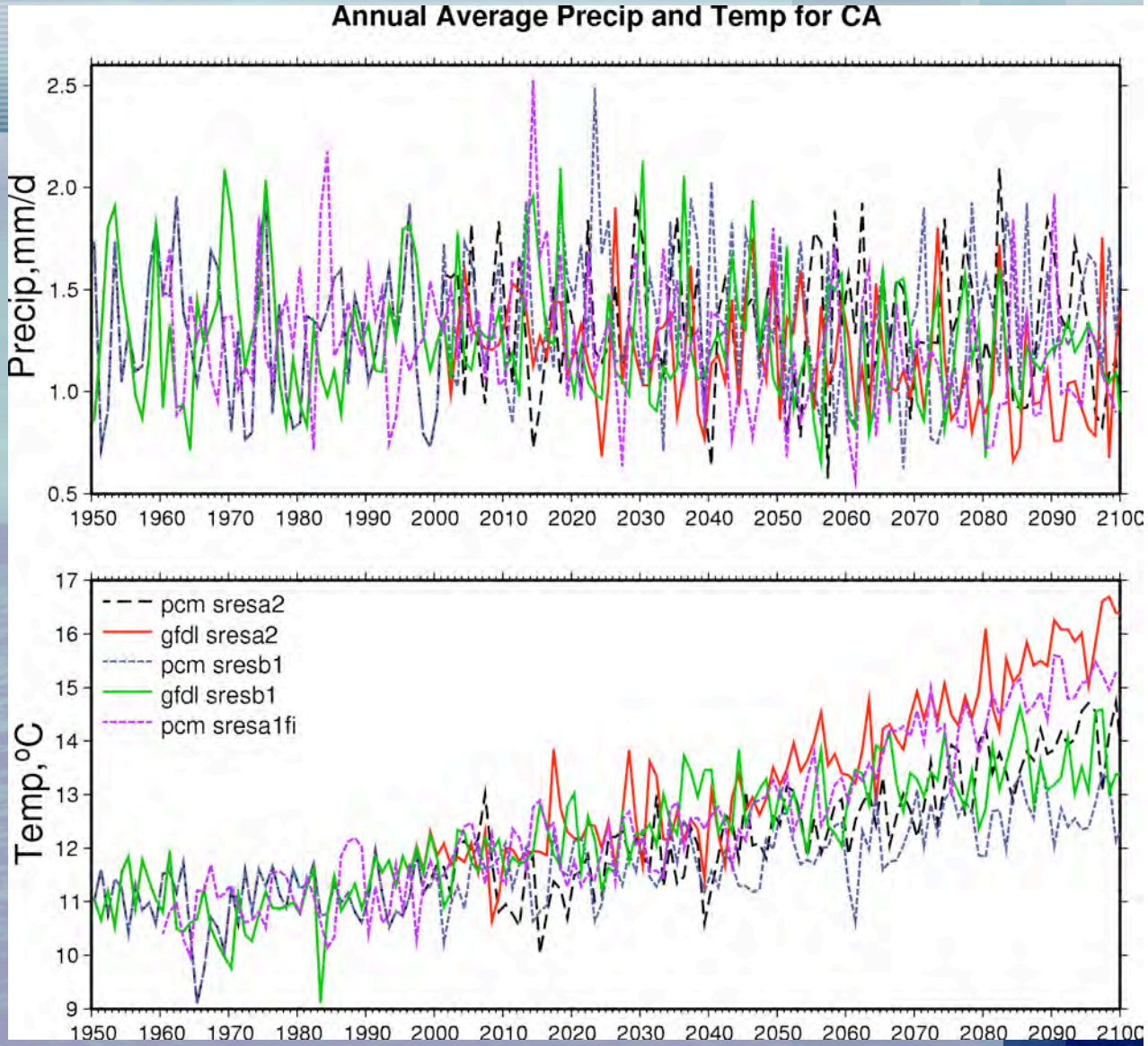
Assumes processes responsible for current precipitation pattern also apply to future precipitation

Results for CA – Annual Average

Annual P trend small, though impacts can be sensitive

T trend strongly influenced by GHG emission scenario and GCM

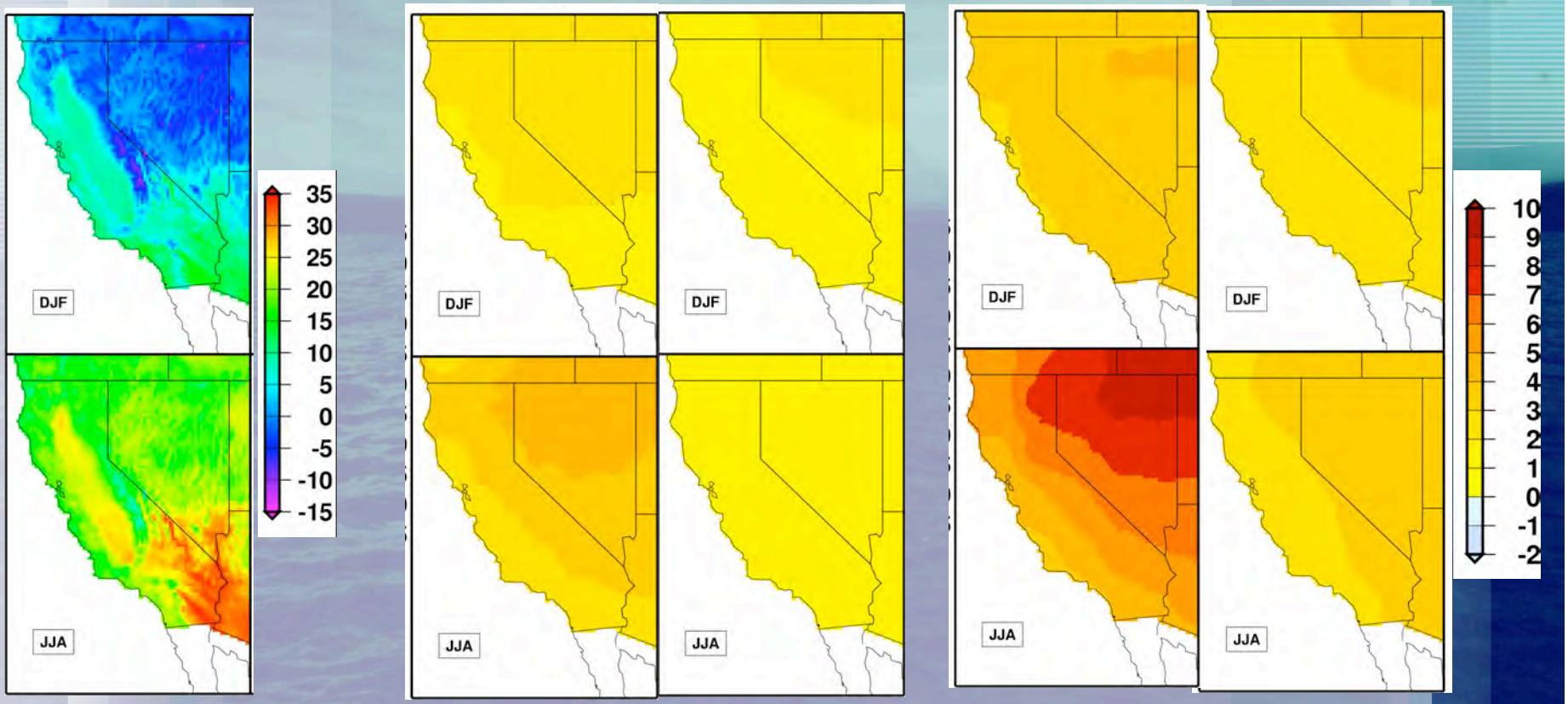
For PCM, A1fi scenario is 1-2 ºC warmer than A2.



Temperature Changes, ºC

	1961-90		B1		A2	
	DJF	JJA	DJF	JJA	DJF	JJA
GFDL	2.2	20.3	+2.2	+3.6	+3.5	+6.4
PCM			+1.9	+1.7	+2.6	+3.2

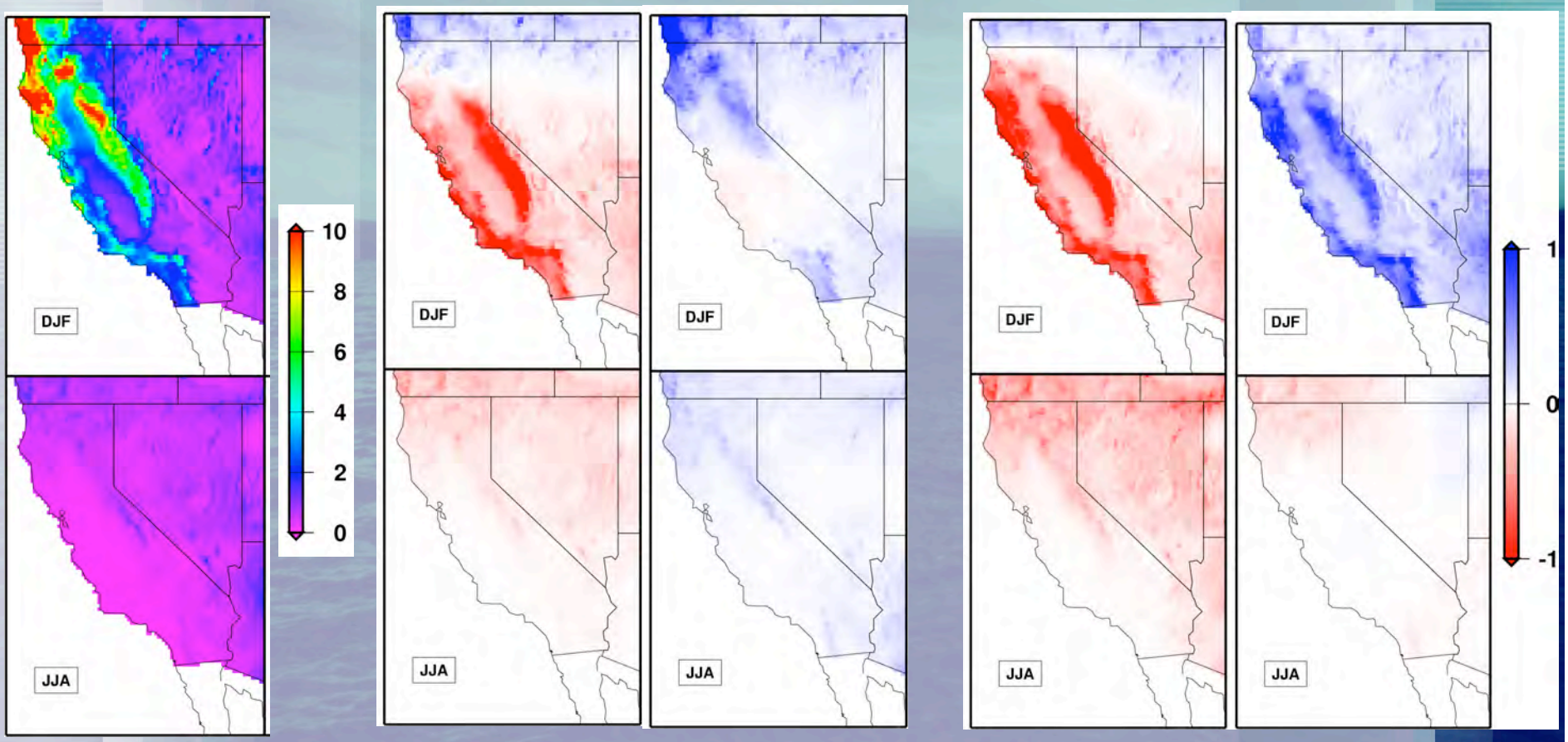
1961-1990 GFDL-B1 PCM-B1 GFDL-A2 PCM-A2



Precipitation Changes, mm/d

	1961-90		B1		A2	
	DJF	JJA	DJF	JJA	DJF	JJA
GFDL	2.3	0.4	-4.9%	-26.7%	-7.2%	-46.7%
PCM			+7.6%	+15.9%	+10.6	-6.8%

1961-1990 GFDL-B1 PCM-B1 GFDL-A2 PCM-A2



1 mm/d ≈ 14 inches/year

Derived data for impact modelers

Downscaled GCM climate and derived meteorology

- •precipitation
- •temperature
- •humidity
- •radiation

Hydrologic model simulations for specific river basins, have produced:

- •streamflow
- •snowpack
- •snowmelt timing
- •soil moisture